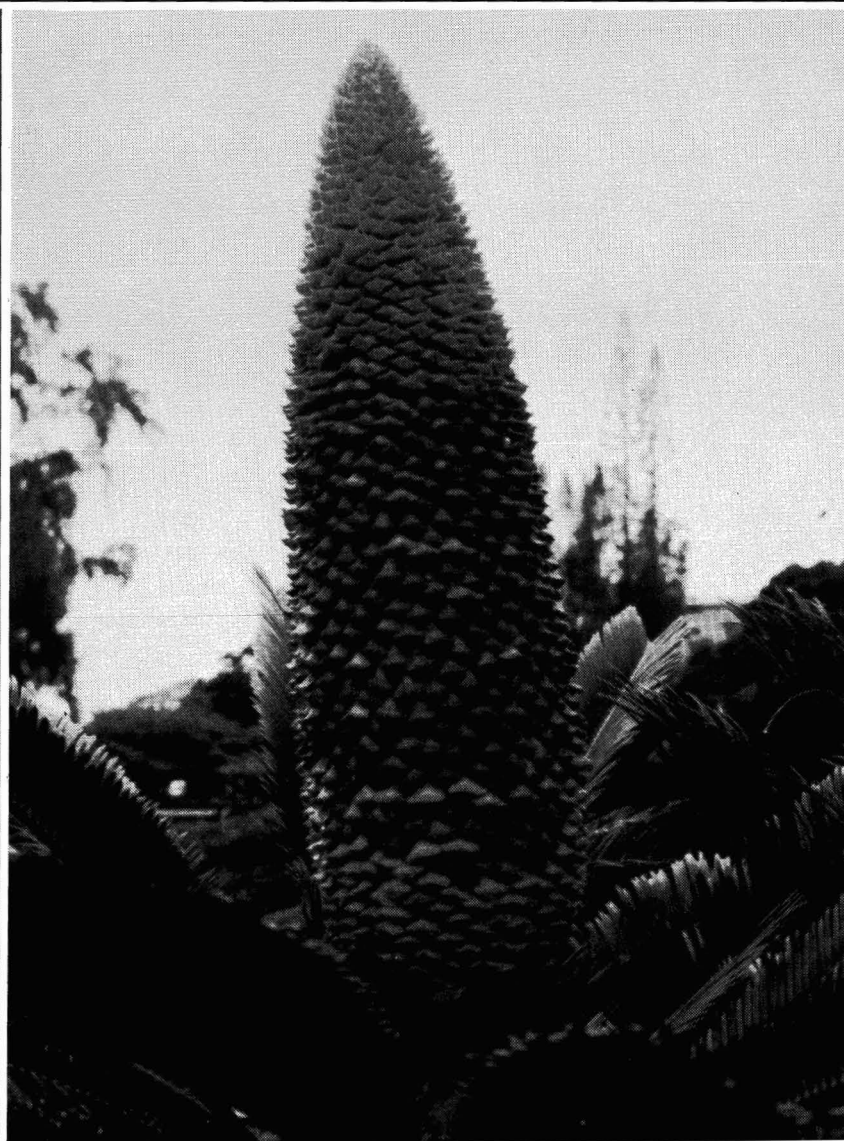


KING AND QUEEN SAGO

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INTRODUCTION

The king sago (*Cycas revoluta*) and queen sago (*Cycas circinalis*) are the most widely cultivated cycads in Hawaii. They are valued as landscape and interiorscape ornamentals and for cut foliage. Production on the island of Hawaii has increased for the export potted and cut-foliage markets.

Cycads include members of the families Cycadaceae, Stangeriaceae, and Zamiaceae. *Cycas*, which is the only genus in the family Cycadaceae, comes from the region that includes Australia, Madagascar, India, China, southern Japan, and some Pacific islands. *C. circinalis* is native to the Old World tropics, from India to the Philippines. *C. revoluta* is native to China and Japan, where it is often used in bonsai.

Cycads are woody, palmlike trees or shrubs, with mostly unbranched trunks that have a large starchy pith. The leaves are pinnate, alternate, in spirals, and remain upwards of three years. Leaf bases are persistent. *C. circinalis* may grow up to 20 feet high with featherlike leaves up to 9 feet long by 2 feet wide. The pointed, glossy, dark green leaflets spread widely, are 0.5 inch wide, and have a prominent midrib (Fig. 1). Short spines line the margins of the petioles (Neal, 1956). *C. revoluta* may grow to 10 feet high with glossy, dark green leaves up to 4 feet long. Leaflets have a midrib with no laterals, and may be 0.25 inch wide and 9.5 inches long, but they emerge at an angle, both ranks forming a slight V, so that the overall width of the leaf may be only 8 inches (personal observation). Leaflet margins are rolled toward the lower side, or revolute, thus the species name *revoluta*.

Cycads are very slow growing. Seedlings produce leaves in sporadic flushes until the plants reach maturity, at about six to 10 years (Middlebrook, 1982). In mature plants a growth flush occurs in early spring to midsummer. The cataphylls (scale leaves surrounding the growing point) elongate, and the mature set of leaves becomes almost horizontal before the flush of new leaves.

Plants are either male or female. In *C. circinalis* and *C. revoluta* the brown male cones are up to 2 feet long by 5 inches thick and erect; they shed pollen from the scales. Cones are generally produced in the spring and summer (Fig. 2), and pollen is shed over four or five days'

time (Kiem, 1972). The fruiting structure in *Cycas* is a whorl of open, leaflike structures called sporophylls, which bear large ovules on the margins. Female trees of *C. circinalis* produce six to 10 ovules on the edges of 1-foot-long, open brown sporophylls. Mature seeds are orange, smooth, and the size of a golf ball (2.5 inches) (Neal, 1965). Female trees of *C. revoluta* produce numerous brown, woolly sporophylls, each up to 9 inches long and bearing approximately six ovules on the margins. The sporophylls curve upward, forming a loose head. Mature seed is red, 1.5 inches long, and somewhat flattened (Bailey and Bailey, 1976; personal observation).

Natural pollination is by wind, but artificial pollination may be used to increase seed set. In South African species of cycads, pollen is viable for three to four days when stored indoors and eight to 10 days when stored in an ordinary refrigerator. For longer storage, pollen can be frozen in airtight containers with a desiccant (Frett, 1987). When the micropylar end of the ovule is sticky, pollen is applied to the ovules (Dehgan, 1983). Pollen can be lightly sprinkled on when dry, or applied wet. The pollen is agitated in water to which one or two drops of a surfactant have been added, and sprayed on the ovules (Kiem, 1972).

Seeds of cycads have an outer fleshy coat, a stony inner layer, and a thin membranous jacket (Fig. 3). The embryo is surrounded by female gametophyte tissue rather than endosperm. This tissue is the nutrient source for development of the embryo. In *Cycas circinalis*, but not in *C. revoluta*, a fourth spongy layer, containing large air spaces, occurs beneath the stony inner layer and may cause it to float (Dehgan and Yuen, 1983).

Cycads are capable of nitrogen fixation by blue-green algae, which are associated with coralloid roots. These roots appear as masses of irregularly shaped nodules close to the soil surface (Dehgan, 1983).

PROPAGATION

Commercially, the current methods of choice are seeds, suckers, and cuttings.

Seeds

Both viable and nonviable seeds of *C. circinalis* will float, while viable seeds of *C.*

revoluta usually will sink (Dehgan and Yuen, 1983). For cycads in general, the sound of rattling when the seed is shaken is a positive sign that the seed is nonviable (Dehgan and Yuen, 1983). Three dormancies are involved in germination: (1) The fleshy coat has an inhibitory effect and should be removed. (2) The stony layer is thick and prevents entry of water into the seed. Sulfuric acid treatment has been found effective for seeds of *Zamia* spp. but may cause injury to those of the queen and king sago, so it is not recommended. (3) The embryo in many cycads, including *Cycas* and *Encephalartos*, is not fully mature at the time the seed abscises. It is generally recommended that seeds of *C. circinalis* and *C. revoluta* be stored for six months (Dehgan, 1983; Frett, 1987). The best seed storage temperature is reported by Dehgan (1983) to be 45° to 50°F, and by Frett (1987) to be 77°F. Seed may be stored dry (Frett, 1987).

The seeds are planted in shallow flats in partial shade and barely covered. In Hawaii success has been obtained in full sun. In transplanting cycad seedlings, care should be taken that they are planted no deeper than at the original soil line.

Suckers

Suckers may be cleanly cut off the base of the parent plant. Leaves are often removed. It is best to take the suckers between growth flushes, i.e., after the leaves have matured but before the next flush of leaves. They are kept in a cool, dry area for one to three days to allow the cut end to dry. Application of a rooting hormone has proved beneficial. A pruning compound that contains auxin (e.g., Tre-Hold[®], which has 1 percent NAA) is sometimes used on the basal cut end. The sucker is placed firmly but not deeply into a well-drained medium. It may be kept in partial shade; in Hawaii it is often kept in full sun. The plant should not be disturbed until it is well rooted, which may take three to four months (personal observation).

Top Cuttings

The trunk of a tree is sometimes cut instead of uprooting the entire tree. Top cuttings such as these can be treated in a similar fashion to suckers. The basal portion will usually produce suckers and adventitious shoots.

Stem Sections

In cycads, disks of the trunk or smaller sections 2 inches or more in thickness have been used for propagation (Dehgan, 1983). They are dried for a few days and treated with a fungicide before planting. This method has not been used

in commercial production of the king or queen sago in Hawaii.

Micropropagation

Research on cycads using female gametophyte tissue, embryos, entire seeds, and newly emerging leaf tips has not been successful for mass production (Dehgan, 1983).

CULTURE

In Hawaii the king and queen sago are grown in full sun or in shadehouses.

In the landscape, soil should be well drained. In container culture, the medium should be well drained and amended with lime as needed. For *Cycas*, a 1:1:1:1 mix of soilless medium, sand, perlite, and pine bark, amended with 5 lb of dolomite and micronutrients, has been recommended (Dehgan, 1983). A mixture of peat and black cinder amended with lime is commonly used in Hawaii.

Cycads should be provided adequate amounts of fertilizer and irrigation, particularly at the time of the flush of new leaves. It has been reported that the number of growth flushes in seedlings is increased by application of N in the form of ammonium (Dehgan, 1983). Nutrition of cycads is an area that needs further work.

The king and queen sago both tolerate interiorscape light levels. Grown in partial shade, the crown is more open and the leaves are longer than when grown in full sun. Light levels above 1000 ft-c have been reported best (Dehgan and McConnell, 1984). Commercially, medium to high light (250 to 500 ft-c) is recommended in interiorscapes (Johnston, 1987).

PROBLEMS

Caution

Roots and seeds of the king and queen sago contain the toxin cycasin, which causes cancer. Seeds of king sago contain poisonous azoxyglycosides (Lewis and Elvin-Lewis, 1977). On some Pacific islands, nervous disorders have been attributed to eating flour made from sago seeds. The food starch sago is obtained from the trunk of a true palm, *Metroxylon*, which is also called sago palm.

Insects

Ten species of scales (black, California red, chaff, Florida red, green shield, hemispherical, oleander, pineapple, purple, and soft), mealybug (*Pseudococcus longispinus*), and dracaena thrips (*Heliothrips dracaenae*) are reported pests on *Cycas* (Pirone, 1978).



Figure 1. Leaves. The larger *C. circinalis* leaflets emerge at a wide angle and have prominent midribs. The *C. revoluta* leaflets emerge at a more acute horizontal and vertical angle, lack prominent midribs, and are a darker green. Note the short spines lining the margins of the petioles.

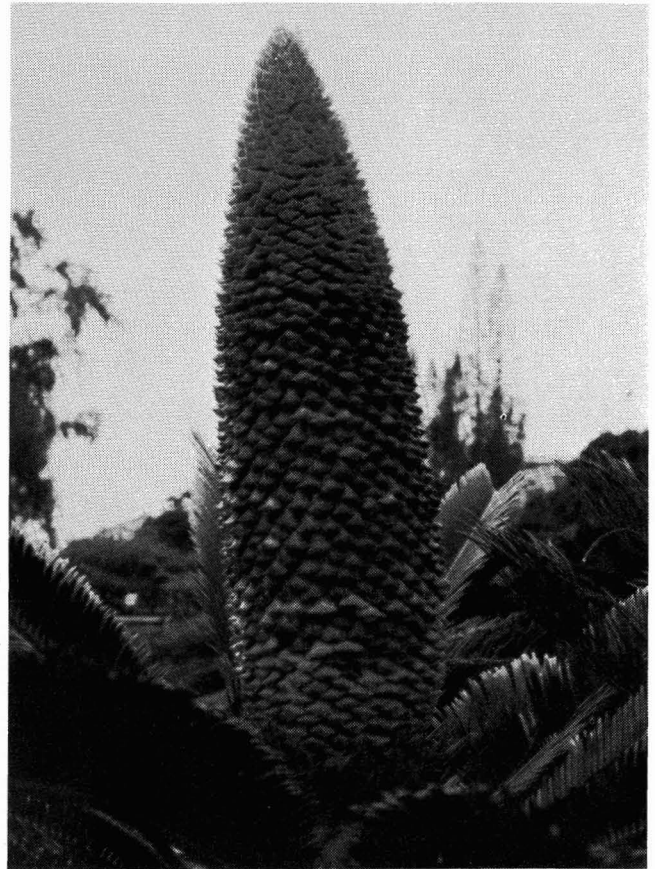


Figure 2. Cone. Male plants of *C. revoluta* produce cones in the spring or summer.

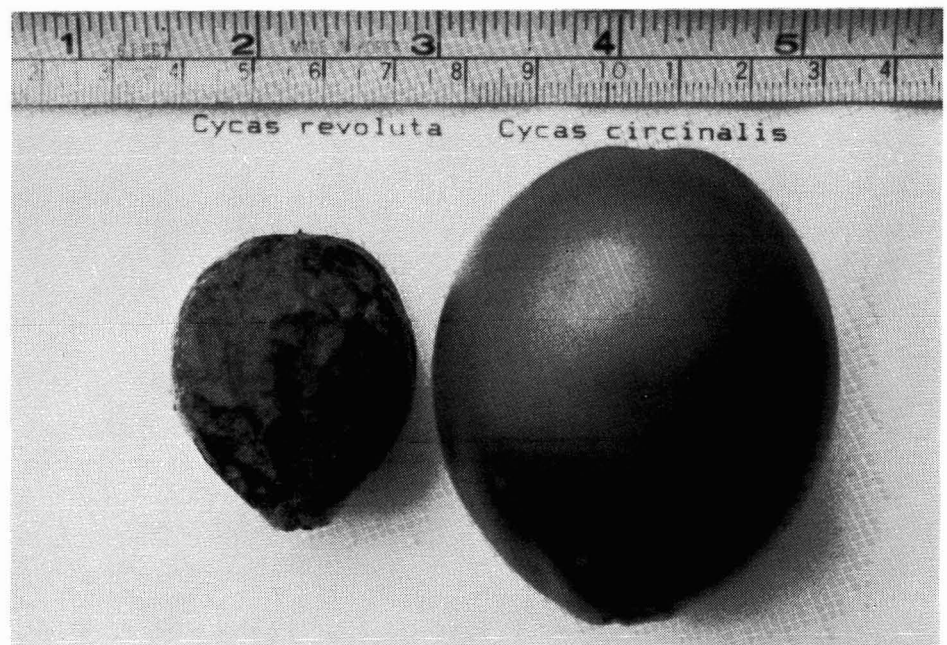


Figure 3. Seed. With timely and adequate exposure to pollen, seed set for *C. circinalis* and *C. revoluta* is good in Hawaii. The *C. revoluta* seed is smooth and plump when fresh.

Leafspot

In Florida the king sago is not recommended for use in the landscape due to leafspotting (Watkins and Sheehan, 1969). A leafspot caused by *Ascochyta cycadina* has been reported in Missouri and Texas. In Florida a blight of unknown cause, which starts with foliar symptoms and eventually kills the plant, has been reported (Pirone, 1978).

Weak Petioles

Occasionally, under shadehouse conditions, petioles on recently matured leaves are incapable of holding the fronds erect. In *C. circinalis* grown in artificial media under shade this symptom was related to low tissue calcium levels (X-ray quantometer reading of 0.07 percent calcium in the symptomatic tissue vs. 0.56 percent in asymptomatic tissue), and it was corrected by application of calcium (personal observation). *C. circinalis* is known to grow in moist regions up to the 1500-foot elevation, and at sea level in calcareous sandy soils.

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